A Knowledge Base Representing Porter's Five Forces Model

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Abstract. Strategic Analysis and Planning is a field in which expertise and experience are key factors. In order to decide on strategic matters such as the competitive position of a company experts heavily lean on their ability to reason with uncertain or incomplete knowledge, or in other words on their experience and expertise. An important aspect is to assess a company's profit potential in the industry for which Porter's Competitive Forces Model is by far the most widely used framework. This article focuses on the various aspects of designing and developing an expert system representing Porter's Competitive Forces Model.

1. Introduction

An important part of the Strategic Analysis and Planning concerns Porter's Competitive Forces Model and it is interesting to see how this well-defined part can be modeled so that the knowledge that it contains can be used in an expert system. This is the main subject of this paper.

Knowledge in the field of strategic analysis is either uncertain or incomplete. An expert in the field generally will not have all data at his disposal. In particular, many data concerning the environment of the enterprise, such as data of competitors and suppliers, will sometimes be missing or is difficult to uncover and thus cannot be taken into account. But also data from within the own enterprise is not always readily available. Whatever the reason for this lack of data may be, the expert is expected to generate an analysis the best he can based on data that is available. Naturally, the more relevant data he can use, the better the quality of the analysis will be. In other words, if the input data is not sufficiently available, conclusions drawn will be correspondingly less certain. This is one of the most striking characteristics of an expert. He is able to come to conclusions based on a limited number of data that - in addition - may also be uncertain. For this purpose he will use his experience. It must also be observed, however, that sometimes an analysis report must be generated in a very limited period of time and then, whether available or not, the number of data used must inevitably be limited. It is obvious that an expert system must also be able to deal with this type of heuristic knowledge and come to conclusions that consequently will also be uncertain.

In the next section a brief survey is given of each of the fields of Strategic Analysis and Expert Systems and how they could be related. In section 3 Porter's Competitive Forces Model is briefly explained and it is discussed how various factors influence the profit potential of a company. Section 4 focuses on aspects such as the representation of this kind of knowledge, the use of business rules, the inference process and reasoning under uncertainty. Finally, in section 5 some conclusions are drawn.

2. Strategic Analysis and Expert Systems

Strategic analysis is a genuinely human task. Experience and expertise are generally considered indispensable for an analyst to assess the many data and circumstances that enter into an enterprise's position. Expert systems claim to perform this task provided that the experience is modeled and processed properly.

In literature relatively little attention is paid thus far to the applicability of expert systems in this specific field. Since the introduction of knowledge-based systems in marketing in the late eighties, a growing interest emerged in expert systems, mostly as a part of decision support systems. The report *Knowledge-Based Systems in Marketing* [1] presents a thorough study of the (potential) role of expert systems in this field and enumerates a number of domains in which special purpose expert systems could be successfully applied. Unfortunately, only a few of the systems developed so far have reached the operational stage. Most systems have not (yet) passed the phase of prototype system.

Also more recent publications indicate that an increasing amount of expert system research is being conducted for a diverse range of business activities [2]. For example, a hybrid system for strategic marketing planning [3] that aims to provide a structured marketing planning process, guides a user through this process, offers expert advice at key stated and finally makes recommendations for users in setting objectives and strategies. It combines the advantages of the expert system and decision support system technology in order to enhance its effectiveness. Another expert system is one in strategic marketing with the objective of helping marketing managers to analyze the position of their company relative to their competitors, in a particular business or product area, and then suggesting ways in which this position might be improved [4]. It is interesting to notice that this subject has a lot in common with the commercially available product Business Insight [5] that is briefly discussed in section 4.

3. Porter's Five Forces Model

A wide variety of schemes visualizing the strategic planning process are available. In essence they usually consists of a series of steps (building blocks).

The analysis starts with defining the business and formulating a vision and then goes on to assess the internal and external environment. The strategic planning process ends with the financial budget and goes into a feedback loop (see figure 1).

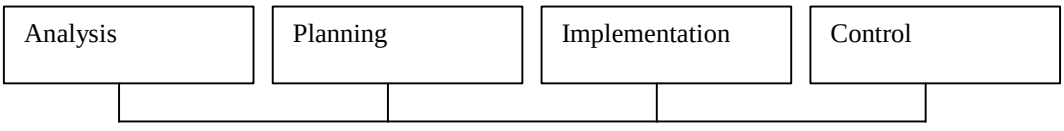

Figure 1: Main steps in the strategic planning process

The essence of formulating a strategy is relating a company to its environment. Therefore the analysis phase is crucial to the outcome of the total planning process. A major part of the analysis phase is a diagnosis of the external environment. Several tools and techniques have been developed to assist the planners in evaluating the external environment. Of particular interest is the assessment of the profit potential in the industry.

Michael Porter's Competitive Forces Model (commonly referred to as Porter's Five Forces Model) is by far the most widely used framework for an assessment of the profit potential in the industry. The collective strength of the so-called five forces (see figure 2) differ from industry to industry.

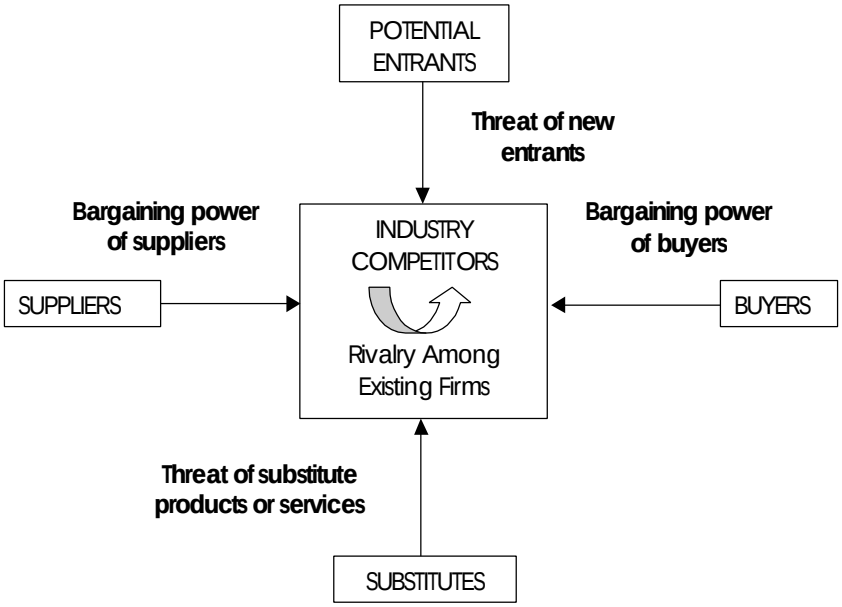

Figure 2: Competitive Forces Model (Porter, 1980, p.4)

Each of those five forces is based on structural features (dimensions) which collectively impact the profit potential. All five forces jointly determine the intensity of the industry competition and profitability. The strongest forces become crucial from the point of view of strategy formulation.

Our goal here is to address the most important dimensions of each of the five forces, for they will be incorporated in the knowledge base (e.g. in the form of business rules) of the proposed expert system. A number of important economic and technical characteristics are critical to the strength of each competitive force. We will discuss them briefly.

Barriers to entry

These are the important structural components with an industry to limit or prohibit the entrance of new competitors. The major components are *scale economies* (advantage of experience, learning and volume), *differentiation* (brand image and loyalty), *capital requirements* (new entrants will face a risk premium), *switching cost* involved by the customer, *access to distribution channels* and *cost disadvantages* (patents, location, subsidies).

Rivalry among existing competitors

In most industries, especially when there are only a few major competitors, competition will very closely match the offering of others. Aggressiveness will depend mainly on factors like number of competitors, industry growth, high fixed costs, lack of differentiation, capacity augmented in large increments, diversity in type of competitors and strategic importance of the business unit.

Substitutes

These are products or solutions that basically perform the same function but are often based on a different technology. Depending on the level of abstraction nearly everything can be a substitution. In general the only factor that really matters is a shift in technology.

Power of buyers

Through their bargaining power buyers can force the competitors to lower their prices or force higher quality or better service. The major factors which determine the bargaining power are volume (relative to seller sales), does the product represent a major fraction of the buyer's costs or purchases, differentiation or standard product, switching costs, buyer profitability (hence their price sensitivity), threat of backward integration, importance to the quality of the final product, and level of knowledge and information of the buyer of industry demand, actual market prices and supplier cost.

Power of suppliers

Suppliers can exert their bargaining power over participants by threatening to raise prices or reduce the quality. A supplier group is powerful if they are more concentrated than the industry they sell to, or if the customer group is not important for the suppliers, if the product is an important input to the buyer's business, or they have built up switching costs, or the supplier group poses a threat of forward integration.

Through addressing these dimensions which make up the Five Forces we have outlined factors which will be taken into account in our expert system. It will still be the expert's insight who will assert the value of impact of each individual variable. Another aspect is the relative weight of each of the factors in the overall assessment.

4. The Expert System

A major representation technique are the so-called business rules, also known as *rules of thumb* when uncertainty plays a role. Business rules commonly have the form:

if < a number of conditions is satisfied > **then** < a number of actions can be carried out >

Mostly actions are of the type: assign a new fact to the domain data base. Each business rule represents a small, single chunk of knowledge and can easily be understood by anyone who is familiar in the field. All of these business rules are combined by the inference engine that can build up a reasoning chain.

In order to build an expert system that represents Porter's Competitive Forces Model it is important to enumerate the factors that contribute to the final conclusion whether or not and if so in which degree a company has a profit potential in its industry. In figure 2 the five forces are enumerated: *Buyers* (bargaining power of buyers), *Potential entrants* (threat of new entrants), *Suppliers* (bargaining power of suppliers), *Substitutes* (threat of substitute products or services) and *Competitors* (rivalry among existing firms).

Each of these forces can be split up in smaller factors that build up to a conclusion about the corresponding force. For example, as mentioned in the previous section, through their bargaining power suppliers can raise prices or reduce quality. This is only possible when they have the power to do so. And a supplier group is powerful if they are more concentrated than the industry they sell to, or if the customer group is not important for the suppliers, or if the product is an important input to the buyer's business. Factors that determine this bargaining power are, among others, the level of the switching costs of materials, how important is the supplier to the enterprise, and in reverse, how important the enterprise is to the supplier, the degree in which the supplies are standardized, whether or not substitute materials are readily available and whether or not the supplier poses minimal treat of forward integration. In Business Insight 5.0 (according to its tutorial, this tool is *'A business factors analysis tool that is used to gather knowledge and formulate strategies for business planning'*) this complex of factors is taken together in a single business rule as follows:

Suppliers have moderate bargaining power (44) since
Cost to switch materials is high (10,6)
Supplier is very important to enterprise (10, 10)
Enterprise is not very important to supplier (20, 10)
Supplies are mostly standardized (70, 10)
Substitute materials are readily available (80,10)
Supplier poses minimal treat of forward integration (100,3)

The first of the two numbers related to each of the clauses indicates the rate on a scale ranging from 0 to 100 in the case under investigation (e.g. in this case the fact that Substitute materials are readily available is rated 80) and this particular clause contributes to the conclusion with a weight of 10 on a scale ranging from 0 to 10). The conclusion that Suppliers have moderate bargaining power has been assigned a rating of 44. This rating is obtained by applying the formula:

$(10*6 + 10*10 + \ldots + 100*3)/(6 + 10 + \ldots + 3) \cong 44$

In order to show how the conclusion Suppliers have moderate bargaining power with a rating of 44 is used in other assertions the following assertion determining the strength of the production operation is helpful (note that this specific clause has a weight 3):

The strength of the production operation is rated (47), since
Enterprise has poor economies of scale (25, 10)
Technology and production experience are unlikely to reduce costs (33, 3)
Production personnel skill level is average (43, 10)
Suppliers have moderate bargaining power (44, 3)
Enterprise has mediocre access to raw materials and personnel (54, 10)
Production manager is average (55, 10)
Enterprise may be cost competitive (60, 6)
Enterprise has fair control of material quality and production (62, 6)

The way Business Insight reasons with its assertions is a form of forward chaining: first the user has to provide all necessary data based on which final conclusions can be drawn.

An obvious drawback of this approach is that it is only helpful when all data are readily available. If data are lacking or incomplete Business Insight does not provide a way how to achieve a valuable conclusion.

The same knowledge can also be expressed by a similar rule that needs to be processed differently. For example, if all clauses of a rule are of more or less similar weight and each clause can be qualified by 'good', 'average' or 'poor', then consequently the conclusion could be either 'good', 'average' or 'poor'. According to some algorithm the choice could be made which of the qualifications have to be chosen for the bargaining power [6].

If
the cost to switch materials is good and
the importance of the supplier to the enterprise is good, and
the importance of the enterprise is poor, and
the standardization of supplies is good, and
the availability of substitute materials Is average, and
supplier's requirement of forward integration is good
then
the bargaining power of the suppliers is average

From the corresponding assertion in Business Insight we learn that not all factors are of equal weight and consequently they are not really suited to be taken together in one single rule. In such a case the rule has to be split up in a number of other rules that meet this requirement of equal weight.

A completely different way of formulating and handling business rules can be achieved by introducing inexact reasoning. This approach circumvents a number of difficulties mentioned in the introduction (such as how to deal with incomplete data which is often a problem) but it also introduces a number of other complications. One of these is how to formulate rules that incorporate uncertainty. An example of this kind of rules is the following:

If
the cost to switch materials is high, and
the importance of the supplier to the enterprise is high, and
the standardization of the supplies is average
then
the bargaining power of the suppliers is high (cf 0.8)

This rule states that the bargaining power is rated as high (with a certainty of 0.8 on a scale ranging from -1 to +1) if all clauses are found to be true. This way of representing knowledge and reasoning is based on the certainty factor model of Buchanan & Shortliffe [7]. It must be noted that each of the clauses of the rule are either the result of one or more other rules or originates from some kind of data source (user, database, etc.). Examples of such rules and how they can be combined to a reasoning chain can be found in [8]. Similar rules may come to the same conclusion although based on different observations such as the availability of materials, the importance of the enterprise to the supplier, etc. Other rules may conclude that the bargaining power is either average or poor based on comparable observations. It will be clear that similar rules can be formulated for the other forces of Porter's model. All these rules together form the knowledge base containing the knowledge of Porter's model. The inference process can still be either forward or backward chaining.

This kind of knowledge representation can be implemented in expert system development environments such as AionDS 7 or Exsys. Both of these environments support inexact reasoning. AionDS 7 also supports building object-oriented models which can be an advantage as discussed in [8].

5. Conclusions

Porter's Competitive Forces Model is a well-defined part of strategic analysis and planning. In this paper it has been discussed that there are several ways to represent the knowledge contained in this model in an expert system. Each of the methods has its pros and cons but the method of inexact reasoning seems to be best suited to deal with uncertain or incomplete knowledge.

6. Literature and References

[1] Wierenga B., *Knowledge Based Systems in Marketing, Purpose, Performance, Perceptions and Perspectives*, Management Report Series, no. 112, Erasmus University Rotterdam, Dept. of Business Management, 1992.

[2] Wong, Bo K. and Monaco, John A., *Expert System Applications in Business: A Review and Analysis of the Literature (1977-1993)*, in: Information & Management [IFM], Vol. 29, Iss. 3, 1995.

[3] Duan Yanqing and Burrell Phillip, *A hybrid System for Strategic Marketing Planning*, in: Marketing Intelligence & Planning, Vol. 13 Iss. 11, 1995.

[4] Moutinho Luiz, Curry Bruce and Davies Fiona, *The COMSTRAT model: Development of an expert system in strategic marketing*, in: Journal of General Management, Vol. 19 Iss. 1, 1993.

[5] User's Manual Business Insight for Windows (An Expert System for Strategic Analysis), Business Resource Software, Austin, Texas, USA, 1993.

[6] Swaan Arons H. de, Jellema M., *An Object-Oriented Model of an Industrial Enterprise and its Environment*, in: Proc. European Simulation Multiconference 1997 (The Society for Computer Simulation International), Istanbul, 1997.

[7] Shortliffe E.H., Buchanan B.G., *A model of inexact reasoning in medicine*, in: Rule-based expert systems, pp. 233-262, Ed.: Buchanan B.G., Shortliffe E.H., Addison-Wesley Publishing Company, Inc., Amsterdam, The Netherlands, 1984.

[8] Swaan Arons H. de, Waalewijn Ph., *Strategic analysis modeled by heuristic knowledge*, Proc. Fourth World Conference on Expert Systems, Mexico City, 1998.